USING CONCEPT CARTOONS

John Dabell describes how he uses 'visual disagreements' to advance his learners' understanding of mathematics.

In the last few years, John Dabell has toured Britain delivering 'Concept cartoons in mathematics' inservice training, spoken at conferences and worked with a focus group of teachers from the City of Edinburgh, writing 20 concept cartoon posters and 120 concept cartoons for a book and interactive CD. These are available from: www.millgatehouse.co.uk

So, what are they? Concept cartoons are cognitive drawings or 'visual disagreements' that use a cartoon-style design to present mathematical conversations inside speech bubbles. The viewpoints portrayed are all different and it is this difference that acts as a catalyst for further conversations, as learners talk together to discuss their thinking. They make learners' ideas about mathematics explicit and they make mathematics interactive and discussion-based. Why has mathematics been so slow to catch on to their potential? As formative assessment tools they have real virtue because they are a highly effective way of probing learners' mathematical conceptions and, crucially, their misconceptions. Presenting alternative ideas encourages everyone to think about things from a different point of view.

Debate and disagreement

What concept cartoons do so well is set up a debate, invite cognitive conflict, inspire dialogue and promote participation. They encourage learners to compare and contrast, to look for evidence and justify their own reasoning in response to the characters in the cartoons. Everyone in the class is expected to have an answer and contribute to the learning conversation and all answers, whether right or wrong, are used as stepping stones to achieve a fuller understanding. They are therefore used as talking tools, to help learners' build on each other's ideas, use each other as sounding boards and work creatively together to make sense of a key idea. Talk is not an optional extra in a concept cartoon, it is an essential ingredient; it is expected.

A disagreement helps set the learning agenda for what happens next in a lesson or series of lessons. A failure to agree is actually a success for learning.

Organisational issues

Concept cartoons are more effective when discussed in a mixed-ability group of learners. This results in a greater degree of exchange and allows different ideas to surface, which can then be debated. They are a particularly valuable tool to employ with learners with special educational needs and learners who require confidence in putting forward their views in mathematical contexts.

There are no hard and fast rules about how to present concept cartoons and it is worth experimenting with different ideas. Traditionally when used in science, one speech bubble contains a correct idea and other speech bubbles present different ways of thinking, ideas that are commonly called 'misconceptions'. It is important to point out here that a misconception is not faulty thinking but 'a concept in embryo or local generalisation', as Malcolm Swan points out in his outstanding book *Collaborative Learning in Mathematics*. In my own research, I have played with the original concept cartoon formula and adapted the speech bubbles for different concepts and different age groups. For example, one correct speech bubble and three incorrect, two correct speech bubbles and two incorrect or all speech bubbles correct.

In this example there are two possible correct answers. The party hats shown are clearly cones but how many learners will recognise them as pyramids with circular cross-sections? You can see why some

children might call the party hats ‘triangles’. Naming them prisms shows us that the properties of 3D shapes are not well understood and are ripe for development. A rich follow-up to this concept cartoon might involve an exploration using actual party hats, getting learners to make their own, examining solid cones and thinking about real-world cones outside of the classroom.

A case study

In my own research into using concept cartoons I have been impressed with the way children have responded to them. I have used a variety of cartoons to address a range of conceptual obstacles and alternative frameworks including the idea of ‘multiplication makes bigger’, which is generally considered a classic mistake. I recently tried the ‘multiplication makes bigger’ concept cartoon in a Y6 class.

© Andy Robb (Beehive Illustration)

There are various ways of bringing this concept cartoon to life. Initially I present the concept cartoon on the interactive whiteboard and ask children to think about each statement privately before discussing it with anyone else. I might take one or two ideas from children at this stage, or do a quick survey with the whole class. This might take the shape of me reading out each statement for children to then draw a smiley face on their whiteboards to indicate whether they agree or not. This tells me a lot about their understanding and children don’t have to worry about being right or wrong as I don’t give them any answers.

I then divide children into small groups of three to talk together to share ideas and ask whether we can ‘make sense of the concept cartoon together’. I make it very clear to children that the focus of the task is on understanding and that understanding is a team effort involving different ways of thinking. Children are encouraged to complete a group table (or ‘thinking board’) where they try to justify their group’s thinking and provide proof for each speech bubble statement. You can imagine the range of responses you might get:

Statement (conjecture)	We agree/disagree	Proof
Multiplying always makes a number bigger	We agree with this statement	We tried 4 × 4, 5 × 6, 7 × 3, 8 × 2, 9 × 9 and these all made bigger numbers
Multiplying by zero means the product is zero	We disagree with this statement	If you multiply by 0 then it gets ten times bigger because you put a zero on the end
Multiplying by a fraction makes a smaller number	We agree with this statement	We did 2 × ½ and this made 1

Statement (conjecture)	We agree/disagree	Proof
Multiplying always makes a number bigger	We disagree with this statement	We tried 1 × 1, and this made the same number. We tried 2 × −2 and this made −4
Multiplying by zero means the product is zero	We agree with this statement	Any number multiplied by zero has a product of zero
Multiplying by a fraction makes a smaller number	We think this statement depends	4 × ½ = 2 but 4 × 3⁄2 = 6

When presented with conflicting evidence like this it is time to seize the moment and milk the maths in order to progress children’s learning. What happens next is crucial. A technique that works well here is to use ‘envoys’ to push children’s thinking further. This involves one person from each group visiting another group to discuss their take on things. I normally do this for about five minutes, after which time the envoys return to their group to share ideas they have picked up and then revise their thinking boards if necessary, after further discussion. The act of writing also helps pupils refine their arguments and summarise their thinking. This is also the time to open up the debate to the whole class in order to showcase particular examples, such as multiplying by negative numbers, proper fractions or improper fractions.

On top of this, I play devil’s advocate, or provide more background information where appropriate, by encouraging particular groups to

think along different lines if they aren't doing so already. I try not to reveal any 'answers' and actually make a point of saying: 'I'm going to ask you *not* to trust what I have to say. You might tell me something and I might agree with you and go along with it or I might disagree and give you something else to think about.'

The most obvious next step is for children to share each others' ideas and focus on proof, trying to convince each other whether they think a statement is conceptually sound or not. This particular cartoon throws up some delightful thinking. Before reaching an end-point, looking through a variety of mathematical dictionaries (book and online) is a worthwhile step so that more evidence can be gathered.

Finally I encourage the children to try and RIP (refine, improve and polish) the statements in the cartoons. For example, the statement '*Multiplying always makes a number bigger*' can easily be disproved. One group thought that it would be more accurate to say '*Multiplying two numbers together sometimes makes a bigger number.*' The statement, '*Multiplying by a fraction makes a smaller number*', was also found to be too vague to be helpful and another group generated their own response, '*Multiplying by an improper fraction makes a number bigger*'. They provided the example, $3/2 \times 4 = 6$. This was challenged by another group who argued that an improper fraction was not always a 'top-heavy' fraction. They researched some website dictionaries to find a definition of an improper fraction as '*a fraction where the numerator is larger than or equal to the denominator*'. They said that 7/7 was an improper fraction which, when multiplied by a whole number, would result in the same product.

From one small statement a whole domino effect is generated, whereby children respond to each other creatively and help build layers of understanding. Leaving the classroom, I am convinced that children have a much stronger understanding of multiplication and that 'multiplication doesn't always make bigger'. As one Y6 learner told me, '*Concept cartoons help you to focus on what you know and on what you have to say.*'

Some conclusions

In all the examples above, it is clear that there is a lot to talk about. Concept cartoons pitch one idea against another. Some of the speech bubbles seem plausible, some are ambiguous and others are way off the mark. Whatever way, they promote 'thought friction', spark ideas and kick-start conversation. Each concept cartoon also requires classroom follow-up in order to investigate the ideas further, explore understandings and practise skills.

One frequently-asked question is which age group concept cartoons are suitable for. This depends. Clearly some of the cartoon characters might not appeal to older learners, but the actual content of the cartoons straddles key stages. Some cartoons have been used successfully with learners in key stages 1, 2, 3 and 4, depending on their prior knowledge. I think concept cartoons are rather like a swimming pool of learners – they hold so many abilities. Some learners are doing lengths, some widths, others struggle to do doggy paddle and some are too afraid to get in! Learners access a concept cartoon at a level that suits them and we are there to supervise them splashing their ideas around and it's our job to help them make waves in their understanding without actually doing the swimming for them.

Using a concept cartoon follows a cognitive conflict model of teaching. Here is one suggestion of a teaching sequence to follow:

- present learners with a cartoon that focuses on a conceptual obstacle
- allow learners to reflect individually on the challenge
- encourage small-group discussion
- provide opportunities for feedback across the class about the alternatives
- try to reach agreement
- discuss a possible line of investigation to find out more
- hold small-group enquiries
- share outcomes of enquiries
- whole-class discussion
- pull ideas together
- consider how learners' views might have changed
- consolidate and practice.

Concept cartoons can be used as lesson starters, develop into whole-class lessons, as plenary activities or as summative assessments. Why not try them in a maths club? Or display some around school to promote discussions amongst parents, carers and visitors? When learners are familiar with concept cartoons, encourage them to create their own or hold a competition. The scope is endless. Give concept cartoons a try and judge for yourself the impact they can have on the rate, depth and breadth of your pupils' learning. Write and let us know how you get on.

John Dabell is a mathematics coordinator at Lawn Primary School in Derby.
john@johndabell.co.uk

References

Keogh, B. and Naylor, S. (2000) *Concept Cartoons in Science Education*, Millgate House

Swan, M. (2006) *Collaborative Learning in Mathematics: a challenge to our beliefs and practices*. National Research and Development Centre for Adult Literacy and Numeracy (NRDC) and the National Institute of Adult Continuing Education (NIACE)